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A FOSSIL FLOWER

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Fig. 1.

A VIEW IN THE CYCAD NATIONAL MONUMENT.

The pick and water bottle in the foreground mark the exact spot where Professor Wieland obtained one of his finest fossil cycads.

Photograph by Mrs. Edith S. Clement.

FIELD MUSEUM OF NATURAL HISTORY
DEPARTMENT OF BOTANY
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A FOSSIL FLOWER

One of the last official signatures of President Harding was affixed to an act establishing the Cycad National Monument, the story of which forms an interesting chapter in the history of recent botanical science.

The tract of land in the southern Black Hills of Dakota thus designated and now set apart "for all time" is neither especially distinguished for grandeur of landscape, magnificence of present vegetation, nor for other openly striking features. Nevertheless it is a place justly famous among botanists the world over.

The locality had attracted attention nearly a century ago. In the course of the adventures related by Edgar Allan Poe in The Thousand-and-second Tale of Scheherazade, Sinbad and his companion encountered an island "where the forests were of solid stone, and so hard that they shivered to pieces the finest-tempered axes. . . ." In a footnote to this tale there is mentioned by way of corroboration "the discovery of a completely petrified forest near the head waters of the Cheyenne, or Chienne River, which has its source in the Black Hills of the Rocky chain."

That an unparalleled record of extinct life of the Reptilian Age lies imbedded in the rocks of this formation was scarcely suspected until about thirty years ago. It was not until then that the locality received

scientific attention[1] and some of its fossil tree trunks were described. They had been looked upon mainly as remains of fairly well-known cone-bearing plants, though among them had been noted stems, suggestive of both tree-ferns and so-called sago palms. These were determined to be fossil cycads of a type already known, especially in Europe, but more perfectly preserved than any hitherto seen. The fame of the locality, however, rests chiefly on the subsequent and surprising discovery that many of these fossil trunks bore actual flowers. These were brought to light by Professor Wieland of Yale[2]. Indicating that real floral structures had originated much earlier than had heretofore been supposed, these ancient and primitive flowers differ in many respects from those of the later true flowering plants and have proved to be botanically of extraordinary interest.

The plants which bore these flowers flourished millions of years ago,[3] when egg-laying monsters were still extant. The common name "Cycadeoid"

1. Professor Thos. H. Macbride of Iowa published the first description of a Black Hills cycad in 1893. Professor O. C. Marsh of Yale soon afterwards made a very extensive collection of the trunks. Professor Lester F. Ward made several reconnaissances of the region and described numerous species of these fossils.

2. Less extensive material of similar kind in less perfect stages of petrification had also been studied by European botanists, but without finality of results, when Professor G. R. Wieland in 1898 began his searching investigation of the Black Hills material, both in the field and laboratory. He was soon able to report surprising discoveries, and to make some of the most critical and important additions to paleobotany, or the knowledge of ancient plants, in perhaps a generation.

3. The age of the formation in which they were found has been variously estimated. On the basis of the disintegration rate of radio-active minerals it exceeds a hundred million years.

The earliest known cycadeoid remains date from the Triassic, the latest from the Cretaceous. Their distribution in time thus covers the entire Mesozoic. The foliage type is even older.

Fig. 2.

A LIVING CYCAD.

(*Dioon edule*).

The living cycads constitute a small and dwindling group, confined almost exclusively to the tropics. The "armour" formed by old leaf-bases remaining on the trunk, is a characteristic feature of the cycads, plainly to be seen in this fine photograph of a Mexican plant.

Photograph by Professor C. J. Chamberlain.

meaning cycad-like, is from the generic name Cycadeoidea used about a century ago by the celebrated Dean Buckland[4] for specimens of their kind from the Isle of Portland on the south coast of England. The Cycadeoids are related to the living cycads which include some so-called Sago Palms, and resemble them in stem structure and foliage, yet the presence of flowers places them in a separate group. Being entirely extinct, they are commonly and not incorrectly spoken of as "fossil cycads", as by using this term in a wide sense the cumbersome technical name is avoided. During the Reptilian or Mesozoic Age, the medieval era in the history of life on earth, the fossil cycads probably constituted at least a third of the vegetation. This age is therefore also known as the Age of Cycads. On the basis of its chief vegetation the succeeding Age of Mammals, which includes the present day, is characterized as the Age of the Flowering Plants. However, it was shown by Professor Wieland's investigations that the dominant types of the vegetation even in the mid-geologic era, had reached an actual flowering stage.

Some plants of the Cycadeoid group were small-leaved and branched, and in general appearance must have been comparable to the simpler forms of modern trees. They were no doubt the very numerous forest members of their kind. The great mass of the petrified forms which have been discovered were thick-stemmed, globular to low columnar plants, mostly unbranched, though some are forked after the manner of cacti. They grew probably on the edge of deserts.

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4. English clergyman and geologist, author of the Bridgewater Treatise on Geology, Dean of Westminster. Buckland had advised with Robert Brown, the botanist, who suggested a family name, the Cycadeoideæ. The term Bennettiteæ is preferred by some botanists.

Trunks of the thick-stemmed kind have been found in a few localities in Europe, in Afghanistan and in India. One such petrified stem, now in an Italian museum, was found in an old Etruscan necropolis or burial place near Bologna, where it had been

Fig. 3.

A FOSSIL CYCAD TRUNK.

(*Cycadeoidea dacotensis*).

Numerous large fructifications enclosed by their bracts are conspicuous among the pits which mark the ends of the leaf-bases. This magnificent silicified trunk was the first specimen described from the Black Hills.

Courtesy of Professor T. H. Macbride.

placed on a tomb by the Etruscans who obtained it from the near-by Apennine hills over four thousand years ago. About a thousand of these trunks have been discovered in the United States. The great mass

of them comes from the Black Hills of Dakota, the most numerous and important specimens being obtained from within the actual limits of the Cycad National Monument. Others have been found in Wyoming, also in Maryland between the cities of Washington and Baltimore, and isolated stems have been collected in Texas, Colorado and California. They were early recognized as fossils, although not always suspected to be plants. Their appearance is unusual and has attracted attention wherever they were found. The miners in the Potomac region kept them as curiosities in their homes, regarding them as fossil beehives and wasp-nests. The workmen in the quarries of Portland, England, where they are encountered, long ago dubbed them "crows-nests." As in the cycads, the leaf bases in these plants remained after the foliage wilted down and now make up the outer layer, or "armour", of the trunks, at the surface of which the spirally disposed ends usually appear as depressions or pits. On this account the trunks were described by some early writers as petrified "masses of coral-cups" or as "clusters of barnacles."

Professor Wieland found his fossil flowers securely encased in this outer layer of the trunks. They were present mostly in the form of unexpanded buds but in many instances fruits had begun to mature. No actually open flowers have ever been found. Naturally any that were present when the chain of events leading to fossilization began, wilted and must have been quickly destroyed, as may be easily surmised after a glance at the delicate expanded structure. It was the fortunate preservation of the well-protected buds in a petrified state that made possible the investigation of their nature. It is likely that these extinct plants, like the century plant or the Talipot palm, flowered only once after a prolonged vegetative period, and then died down. The flowering must have

Fig. 4.

A FOSSIL CYCAD IN FLOWER.

This figure represents the conception of the famous paleobotanist, Nalthorst. The original painting is in the National Museum, Stockholm.

Courtesy of Professor G. R. Wieland.

been profuse, for some of the trunks preserved in the critical stage show upwards of five hundred buds. The position of the flowers on the old part of the trunk is unusual, but is not entirely unique, for a somewhat similar flowering habit is to be seen among some of the tropical forest trees.

Fig. 5.

A FOSSIL CYCAD FLOWER.

(*Cycadeoidea ingens*).

Photograph of the model in the Field Museum of Natural History.

By the use of a tubular drill, Professor Wieland removed the buds and fruits from the petrified trunks. The cores thus secured were sliced and polished, so that the structures enclosed became plainly exposed

to view. The preservation is often so perfect that microscopic details, such as pollen grains, may be as clearly observed as in living plants, and the study of an abundance of sectioned material has resulted in a clear comprehension of the structure.

The most striking feature of one of these flowers

Fig. 6.

A FOSSIL CYCAD FLOWER.

(*Cycadeoidea ingens*).

Photograph of the model in the Field Museum of Natural History. Same as fig. 5, seen from above.

is its branched stamens, which number a dozen or more, resembling the fertile fronds of certain ferns. The stamens are laterally united at the base and fused to a corolla-like "disk." The disk with the

stamens was thrown off as soon as the function of the latter was fulfilled. Similar but simpler disks had previously puzzled geologists who found them as detached specimens in various places. The center of the flower is occupied by a seed-producing cone, as is the case in the magnolias, especially in the tulip tree. In its minute structure the fossil cone is, however, quite different from that of these flowering trees, for the seeds are still naked instead of enclosed as in the present true flowering plants. Below the disks are numerous bracts, or "sepals", as they would be called in a modern flower. These constituted an outer protecting envelope which remained to surround the fruit as it matured. All the usual parts of a flower are seen to be present and disposed in the usual sequence. This fossil flower is thus unmistakably a flower according to all definitions—"the flower of Linnaeus, of Goethe, and of Payer", as their discoverer states.

It is quite natural to ask, what may be the connection between these ancient flowers and those of the modern flowering plants.

The origin of the flowering plants proper is obscure. Their first appearance as leaf-impressions in the rocks dates from the latter half of the Age of Cycads. From the numbers and the considerable variety of their earliest traces, it is certain that they were then already far advanced. A long evolutionary history, which remains unknown, unquestionably lies behind their sudden rise to visibility. It was this late and apparently abrupt appearance of the flowering plants that was referred to by Darwin as an "abominable mystery."

In the absence of fossil clues, the origin of the now dominant flowering plants is an unsolved problem in spite of the intensive study of living plants that has been carried on for generations. Botanists are

not agreed as to which of the many kinds of flowering plants may be assumed to be most primitive and to represent the nearest approach to an ancestral type. Indeed, botanical classification of the flowering plants is expressive of the uncertainty which prevails.

Such being roughly the state of our knowledge —or ignorance—of the origin and primitive state of the true flowering plants, the question inevitably arises whether the ancient flowers of the fossil cycads

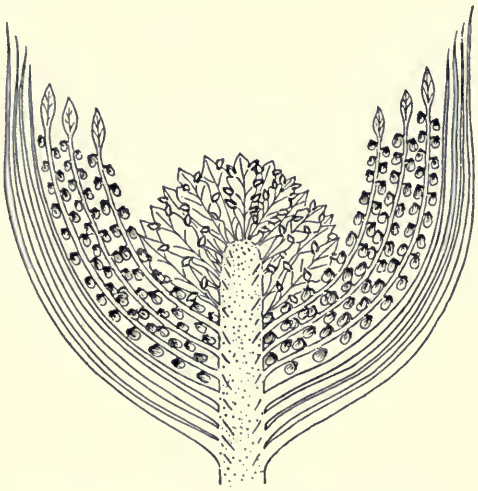

Fig. 7.

A schematic flower of a hypothetical stock ancestral to cycads and flowering plants.
From Arber and Parkin.

may not represent the ancestral type. The particular one described and figured here is considered much too specialized to be the ancestor of anything. It must rather be considered, with the plants to which it belonged, to have been an end-product, or a final development in a vanishing line. However, some flowers of simpler fossil cycads of a less peculiar habit of growth have also been discovered. The degree of relationship of the fossil cycads to the stock from which

the flowering plants sprang has not been defined, but the consensus of opinion seems to be that the two lines are at best only distantly connected. The nearest relationship that appears to be possible is a connection by common descent from a still older group.

Nevertheless it is difficult to escape the growing conviction that these fossil flowers shed light on the early floral structure of the true flowering plants. It is tempting to assume, at least by the way of hypothe-

Fig. 8.

A purely hypothetical primitive flower of the true flowering plants.

From Arber and Parkin.

sis, that the ancestors of these bore flowers organized on a similar plan.[5] The well-known English authority, Scott, thus says of the cycadeoid flowers, that they "for the first time brought the origin of the flowering plants within the range of scientific discussion."

The alterations which would be required to transform the cycadeoid flower into that of the later flowering plant can easily be specified. Restorations of

5. "The cycadeoid flowers show the possibilities and trends of variation and even the lines along which variation could primarily occur." Wieland.

hypothetical ancestral flowers have been attempted by Wieland and others on this basis and visualized by the English botanists Arber and Parkin as reproduced in Figures 7 and 8. If their conception is accepted as correct in principle, the so-called "strobilus theory" of the flower becomes the only tenable one. According to this the various parts of the primitive flower were disposed in the form of a cone, terminal on the flowering axis. Its seed-bearing members were placed

Fig. 9.

A TULIP-TREE FLOWER.

The carpels are seen to form a strobilus or cone. In the magnolia the stamens are more numerous and arranged in a more definitely spiral manner.

From Sargent.

at the tip, followed in order by stamens and below these by the sterile members which are generally known as petals and sepals. The parts are assumed to be indefinite in number, and spirally arranged. The most primitive flowers, according to this theory, are those of the magnolia order, with the tulip tree flower approaching perhaps more closely than any other to the ideal type.* This well-known theory has long been entertained by many botanists who now find support

* Wieland, 1901.

for their views in these fossil flowers. Others, more skeptical, refuse to attach any special significance to the older cycad floral type taken as a hypothetical "missing link."

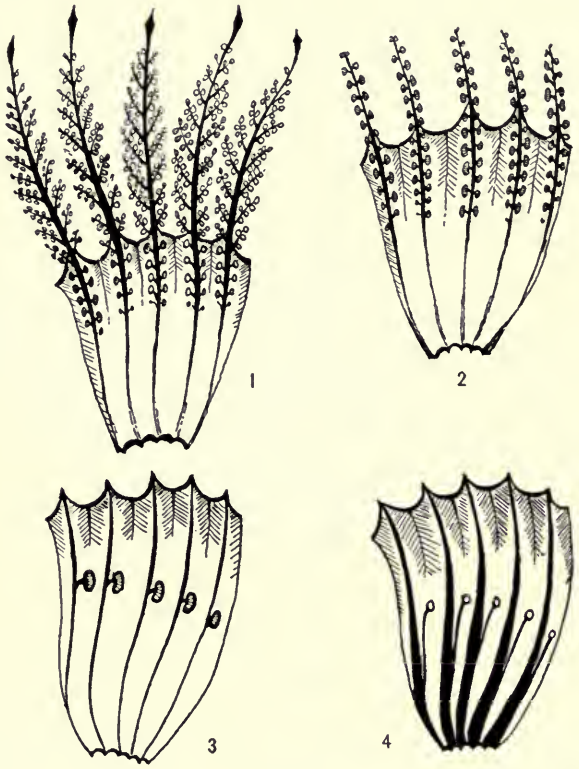

Fig. 10.

Stages in the reduction of stamens from the frond-like condition in fossil cycad flowers (1. *Cycadeoidea*, 2. *Williamsonia*), through a hypothetical intermediate stage (3), to the condition in a flowering plant such as the morning-glory (4).

From Wieland.

The presence of the bell-shaped disk uniting the stamens has led to some speculation, particularly since it has also been found in another cycadeoid with

unbranched stamens. Professor Wieland[6] points out, that with the stamens reduced to simplest form, this disk or "campanula" would make a perfect corolla of the morning-glory type. The possibility is suggested that this feature may have been present also among some members of the primitive flowering stock and that the origin of the corolla of many flowers of the tubular type may be far more ancient than is is ordinarily supposed. Such are a few of the botanical questions which are raised.

Entirely apart from their theoretical importance and possible bearing on the evolutionary history of the flowering plants, these early flowers are in themselves objects of great interest. Considering the perishable nature of flowers and the delicate character of many of their parts, the fact of their perfect preservation through millions of years seems remarkable. To bring to light and to restore with confidence extinct flowers which bloomed at the time when the earliest birds were learning to fly is no small achievement. The published results of Professor Wieland's investigations fill two large illustrated volumes issued by the Carnegie Institution of Washington, and a third, of equal interest, published by the Geological Institute of Mexico.

Realizing the desirability of conserving the site that yielded these fossil trunks, Professor Wieland had the foresight to secure its immediate protection by filing a homestead claim to the tract of 320 acres. It is due to his initiative that this tract, which he later released for the purpose, is now preserved as a National Monument of unique botanical interest.

A reconstruction or model of this fossil flower as restored by Professor Wieland has been produced with his cooperation in the Stanley Field Laboratories

6. Wieland, G. R., Botanical Gazette, Dec. 1909.

of the Field Museum of Natural History. It will be placed near the modern cycads in the hall devoted in this Museum to a synopsis of the plant-life of the world.

B. E. DAHLGREN.

Fossil Cycad trunks and leaves are found in the exhibits of the Department of Geology in the west hall (Hall 38) on the second floor.

In the Department of Botany the Cycads are to be seen in the Hall of Plant Life, in the east hall (Hall 29), also on the second floor.